R E P O R T R E S U M E S

ED 013 898 VT 001 218

THE USE OF CHEMICALS AS FUNGICIDES, BACTERICIDES AND NEMATOCIDES. AGRICULTURAL CHEMICALS TECHNOLOGY, NUMBER 4.

OHIO STATE UNIV., COLUMBUS, CENTER FOR VOC. EDUC.

PUB DATE DEC 65

EDRS PRICE MF-$0.25 HC NOT AVAILABLE FROM EDRS. 57P.

DESCRIPTORS- *TEACHING GUIDES, UNITS OF STUDY (SUBJECT FIELDS), *AGRICULTURAL EDUCATION, *AGRICULTURAL CHEMICAL OCCUPATIONS, *PLANT PATHOLOGY, POST SECONDARY EDUCATION, BIBLIOGRAPHIES,

THE PURPOSE OF THIS GUIDE IS TO ASSIST TEACHERS IN PREPARING POST-SECONDARY EDUCATION STUDENTS FOR AGRICULTURAL CHEMICAL OCCUPATIONS. ONE OF A SERIES FOR THESE OCCUPATIONS, THIS MODULE WAS DEVELOPED BY A NATIONAL TASK FORCE ON THE BASIS OF DATA FROM STATE STUDIES. SECTIONS ARE (1) PLANT DISEASE AND NEMATODE PREVENTION, CONTROL, OR ERADICATION WITH CHEMICALS, (2) TERMINOLOGY AND COMPUTATIONS, (3) PATHOLOGICAL AGENT AND NEMATODE IDENTIFICATION, (4) FUNGICIDES, BACTERICIDES, AND NEMATOCIDES, (5) CHEMICAL UTILIZATION PRINCIPLES AND CONCEPTS, (6) UTILIZATION SKILLS AND ABILITIES, AND (7) LEGAL HANDLING, STORAGE, AND APPLICATION OF CHEMICALS. IN ADDITION TO SUGGESTIONS FOR INTRODUCING THE MODULE, THE GUIDE INCLUDES OBJECTIVES, SUBJECT MATTER CONTENT, TEACHING-LEARNING ACTIVITIES, AND INSTRUCTIONAL MATERIAL AND REFERENCES FOR EACH SECTION. IT IS DESIGNED FOR 24 HOURS OF CLASS INSTRUCTION, 36 HOURS OF LABORATORY EXPERIENCE, AND 80 HOURS OF OCCUPATIONAL EXPERIENCE. TEACHERS SHOULD HAVE A BACKGROUND IN AGRICULTURAL CHEMICALS, AND STUDENTS SHOULD HAVE POST-HIGH SCHOOL STATUS, APTITUDE IN CHEMISTRY, AND AN OCCUPATIONAL GOAL IN THE FIELD. THIS DOCUMENT IS AVAILABLE FOR A LIMITED PERIOD FOR $6.75 PER SET (VT 001 214 - 001 222) FROM THE CENTER FOR VOCATIONAL AND TECHNICAL EDUCATION, THE OHIO STATE UNIVERSITY, 980 KINNEAR ROAD, COLUMBUS, OHIO 43212. (JM)

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ED013898

THE USE OF CHEMICALS AS FUNGICIDES, BACTERICIDES AND NEMATOCIDES

AGRICULTURAL CHEMICALS TECHNOLOGY
No. 4

The Center for Research and Leadership Development
in Vocational and Technical Education

The Ohio State University
980 Kinnear Road
Columbus, Ohio 43212

The development of these materials was supported by a grant from the
Division of Adult and Vocational Research
United States Office of Education

December, 1965

VT001218

M E M O R A N D U M

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DATE: August 7, 1967

RE: (Author, Title, Publisher, Date) Module No. 4, "The Use of Chemicals as Fungicides, Bactericides, and Nematocides," The Center for Vocational and Technical Education, December, 1965.

Supplementary Information on Instructional Material

Provide information below which is not included in the publication. Mark N/A in each blank for which information is not available or not applicable. Mark P when information is included in the publication. See reverse side for further instructions.

(1) Source of Available Copies:
Agency The Center for Vocational and Technical Education
Address 980 Kinnear Road, Columbus, Ohio 43212
Limitation on Available Copies No Limit Price/Unit $6.75/set
(quantity prices)

(2) Means Used to Develop Material:
Development Group National Task Force
Level of Group National
Method of Design, Testing, and Trial Part of a funded project of the USOE, OE-5-85-009; materials based on research from state studies; see preface materials in the course outline.

(3) Utilization of Material:
Appropriate School Setting Post High School
Type of Program Intensive, full-time, two-year, technician program
Occupational Focus Goal in the Agricultural Chemicals Industry
Geographic Adaptability Nationwide
Uses of Material Instructor course planning
Users of Material Teachers

(4) Requirements for Using Material:
Teacher Competency Background in agricultural chemicals
Student Selection Criteria Post high school level, aptitude in chemistry, high school prerequisite, goal in the agricultural chemicals industry.
Time Allotment Estimated time listed in module. (P)

Supplemental Media --
Necessary x
Desirable
(Check Which)

Describe Suggested references given in module. (P)

Source (agency)
(address)

This publication is a portion of the course material written in Agricultural Chemicals Technology. To be understood fully, the complete set of materials should be considered in context. It is recommended that the following order be observed for a logical teaching sequence:

#1 - The Use of Chemicals as Fertilizers

#2 - The Use of Chemicals as Insecticides - Plants

#3 - The Use of Chemicals as Soil Additives

#4 - The Use of Chemicals as Fungicides, Bactericides and Nematocides

#5 - The Use of Chemicals to Control Field Rodents and Other Predators

#6 - The Use of Chemicals as Herbicides

#7 - The Use of Chemicals in the Field of Farm Animal Health (Nutrition, Entomology, Pathology)

#8 - The Use of Chemicals as Plant Regulators

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THE USE OF CHEMICALS AS FUNGICIDES, BACTERICIDES, AND NEMATOCIDES - PLANTS

Major Teaching Objective

To develop skills and abilities needed for entry and advancement by technicians in occupational work which has to do with the chemical control of plant diseases and nematodes.

Secondary Objectives

1. To develop an interest in and an appreciation of the part which chemicals have in controlling plant diseases and nematodes.

2. To gain an understanding of the principles of plant growth, soil science, and chemistry as they relate to the effective use of fungicides, bactericides, and nematocides.

3. To gain knowledge and skills essential to the qualification of technicians for work in the areas of plant disease and nematode control.

Suggested Time Allotment

At School		
Class Instruction	24 hours	
Laboratory Experience	36 hours	
Total at School		60 hours
Occupational Experience		80 hours
Total for Course		140 hours

Suggestions for Introducing the Course

Farmers, like all other businessmen, are subject to the same general and social and economic forces which affect the nation's general economic condition. However, some factors of production are peculiarly agricultural. The presence of plant diseases is one

of these. Plant diseases must be studied within the framework in which they are influential. The relationships of environment and host to plant disease is often a complex one. Economically efficient production and the welfare of the national economy require that we prevent unexpected seasonal fluctuations in production of food and fiber. Violent fluctuations are most likely to be caused by the destructive effects of epidemics of plant diseases, plagues of insect pests, extreme heat or cold, and droughts or floods. The technician who would control plant diseases and nematodes through the use of chemicals will find it necessary to understand much in order to be effective in his work.

The following suggestions may be useful in arousing a high level of interest in the students at the beginning of this unit:

1. With information obtained from workers in industry, business, public service, and education, develop a list of skills, abilities, and understandings which agricultural chemical technicians need for employment in the fields of plant disease and nematode control. The list will probably include entries for each of the following sub-headings:

    a. Man's use of chemicals to attempt to control plant diseases and nematodes.

    b. Federal, state, and local laws, regulations, and controls which pertain to the use of fungicides, bactericides, and nematocides.

    c. The recognition and identification of plant diseases and nematode injury which are commonly encountered.

    d. The nature of various chemical resources which are available for use to control plant pathogens and nematodes.

    e. The principles of plant growth, soil science, and chemistry which are related to the use of chemical control of plant diseases and nematodes.

    f. The skills, abilities, and understandings needed to plan effective plant disease and nematode control programs.

    g. Important terms, nomenclature, definitions, tables, charts, and guides common to the field and also important computations, calculations, conversions, and measurements performed.

    h. The safe handling and applying of fungicides, bactericides, and nematocides in the proper manner, using approved methods and equipment.

2. Have the students assist in developing a list of the factors which tend to complicate the task of controlling plant diseases and nematodes through the use of chemicals. Such a list might include the following:

   a. <u>For plant diseases</u>

      1) There is considerable variability in the effects of pathogens under different environmental conditions.

      2) The composition of populations of pathogenic organisms varies greatly in their expression on plants.

      3) New strains or races result very often from hybridization between bio-types within species, between different species, and between some genera. Mutants are common (more than 400 strains of tobacco Mosiac for example).

      4) Man's knowledge is exceedingly limited with regard to plant pathogens.

      5) Viruses and other pathogens may be present in a plant without evidencing any symptoms.

      6) Many strains and kinds of pathogens attack at one time - difficult to treat.

      7) Many pathogens are prodigiously prolific and easily dispersed.

      8) New strains differ in symptoms, severity of disease produced, infectivity, longevity, dilution end point, thermal inactivation point, amounts and kinds of amino acids, temperature range for multiplication, invasiveness, rate of movement in tissues, extent to which they become systemic, types of primary and secondary lesions, geographical distribution, rate of spread, effect on yield, host range, specific insect vectors, mutabilities, serological and immunological reactions.

      9) The genetic diversity and phenotypic variability of many of the most destructive pathogens are so great as to create extremely complex problems of disease control in the present and to raise the question as to how complex they become in the future.

      10) Symptoms of disease caused by pathogens sometimes resemble very closely the symptoms of stress in a plant caused by other causative factors. It is difficult under these circumstances to identify one from the other or to identify the actual origin of trouble.

b. Nematodes

1) Increase in economic importance each year

2) Limited amount of knowledge about certain nematodes

3) Exceedingly small and diverse

4) A very wide range of hosts for some groups

5) Rapid dispersion, difficult to control

6) Symptoms of infestation often resemble other stress symptoms

3. List the kinds of chemicals the students are familiar with that are available for use to control plant diseases and nematodes.

4. Have the students consider:

a. Up until about 1940, what measures were used to control plant diseases? Nematodes?

b. From about 1940 until the present, what control measures have been used to control plant diseases? Nematodes?

c. What measures do you think we will be using to control these pests in 1975 (less than 10 years). Possibilities: irradiation, ultrasonic shock waves.

Competencies to be Developed

I. To develop an interest in and an understanding and appreciation of man's use of chemicals to attempt to prevent, control, or eradicate plant diseases and nematodes.

Teacher Preparation

Subject Matter Content

Note: Review important aspects of plant pathology, soil science, plant growth, and chemistry as they relate to a study of fungicides, bactericides, and nematocides. Examine the magnitude and importance of the disease and nematode problems confronting man and the attempts he has made to modify the situation.

1. The problem or setting

a. The need to control organisms which cause plant disease

Man's every step forward has been and continues to be challenged by competitors we call pests--insects, disease producing organisms, weeds, rodents, and other similar pests. They devour growing crops, destroy harvested grain and other stored products, denude the forests, attack our livestock, invade our homes, and spread some of the most dreaded diseases of man and beast.

Cultivated crops grown in North America are attacked by more than 3,000 economically important species of insects, as well as many plant disease agents, and unestimated numbers of nematodes, rodents, weeds, and other competitors. Estimates of the destruction caused by agricultural pests made independently by several agencies range somewhere between 8 and 15 billion dollars annually - a quarter of our annual production - and this despite the widespread use of the best control practices now available. In 1954, the U.S. Department of Agriculture estimated that crop losses caused by pests make necessary the cultivation of an extra 88 million acres each year, and that crop losses subsequent to harvest equal the production of an additional 32 million acres. It seems possible man stands to gain by an intensification of pest control that might lead to the release of all or a part of these 120 million wasted acres for use as wildlife refuges or recreational areas.

The plant disease problem must be measured not only by the actual damage caused by the disease but also by the costs of preventive and control measures and by the limitations that diseases impose on the kinds and varieties of crops that can be grown in an area.

In the United States the average annual loss from plant diseases is estimated to be about 3 billion dollars. Some would observe that the economic importance of plant diseases is secondary to the consideration that, but for the production of plants, life itself would not be possible.

Wholly aside from the economics of agricultural production, adequate pest control is made mandatory by state and federal laws that provide for the establishment of market grades which regulate the distribution and marketing of food products. We must also recognize that the provisions of the Food, Drug, and Cosmetic Act apply equally to any and all types of food contaminants, regardless of whether they are biological or chemical in nature. The Food and Drug Administration's annual reports show that each year literally thousands of tons of food are seized as unfit for human consumption. Roughly three-fourths of all these seizures are attributable to filth or decomposition, which of course includes the presence of insects, insect fragments, molds, fungi, bacteria, and other undesirable organisms.

In the light of these facts, the Food Protection Committee of the National Research Council has said, "Plant and animal pests rank among the foremost causes of food destruction, deterioration, and contamination. Hence, the absolute necessity of protecting growing crops and products from serious attack by insects, plant diseases, and other pests is recognized as essential from the standpoint of both quantity and quality of the food produced."

(The instructor may, at this point, want to briefly go into a breakdown of monetary losses and costs, effects of disease on the production of crops, and the effects of disease on plant products.)

2. Possible courses of action

   a. Methods of controlling/preventing plant diseases

      The control of plant diseases is complicated by many factors and only infrequently will one method alone give completely satisfactory control of a specific plant disease. Plant disease control methods may be grouped into two major categories.

      1) Immunization (render immune)

      2) Prophylaxis (prevention of disease development)

   b. Immunization

      1) Genetic resistance

      2) Chemotherapy

c. Prophylaxis

1) Protection

a) Chemical Prophylaxis

b) Environmental manipulation

2) Legislation

a) Quarantines

b) Regulatory measures

3) Eradication

a) Crop rotation

b) Sanitation

c) Alternate host elimination

d) Chemical eradication

d. The foregoing categories are often outlined under one of the following

1) Biological control

2) Cultural control

3) Chemical control

3. Review pertinent aspects of previous studies

a. Plant pathology

b. Plant growth and nutrition

c. Soil science

d. Introductory entomology

4. The use of chemicals to control plant diseases

a. Surface protection

1) Seed

2) Foliage

3) Fruit

b. Systemic protection

1) Chemical prophylaxis

2) Chemotherapy

a) Nutritional

b) Antiparasitic

c) Antipathogenic

3) Eradication

a) Surface eradication

b) Soil fumigation

c. Examples of well-known control programs. (Cite local examples if possible.)

1) Peach yellows in many parts of the country

2) Curly top of sugar beets

3) Fire blight of pear

4) Verticillium wilt of cotton

5. Major determinations which need to be made in order to develop a chemical control program

a. Kind of chemical to use

b. Time to use

c. Placement

d. Amounts needed

e. Concentration to use

f. Method of application

g. Form of chemical to use

h. Ease of application

i. Relative safety in using

j. Cost

k. Toxicity

l. Residue danger - tolerance allowable

m. Drift danger

6. What are some of the results generally obtained as a result of using fungicides and nematocides?

a. Elimination is most desirable but not very probable. Aim is therefore to reduce the severity of the pathogen and possibly allow for some control by another means.

1) Generally, satisfactory results can be secured both in prevention and control by partial elimination of pathogens.

2) Varieties and species can be grown in areas when otherwise they could not be raised.

3) Plant and pesticide research programs develop new materials and products for use about as fast as new strains of pathogens appear.

4) Higher yields of improved quality product

5) Insects are easier to control if disease control program is effective.

7. Problems encountered in using fungicides and nematocides

a. Health and safety hazards inherent in some operations with some chemicals

b. Difficulty to secure satisfactory application

c. Drift of applied materials

d. Danger to desirable plant and animal life

e. Difficulty in identifying the origin of plant stresses

8. The fungicide and nematocide industry

a. History and development

(Sharvelle - The Nature and Uses of Modern Fungicides - presents excellent review on fungicides in Chapter 1)

(Thorne - Chapter 1 in Principles of Nematology - gives comprehensive review of nematocides)

b. Present status and situation

1) Extent of pathogens

2) Extent of chemical resources for use to control fungi, bacteria, nematodes in agriculture

3) Number of major firms producing pesticides for use in plant disease control

4) The extent pesticides are used to control plant diseases locally, nationally

c. Recent changes and future trends

1) Changes

a) Phytrons have been constructed which allow a higher degree of environmental control and acceleration of research with fungicides and nematocides.

b) Much has been accomplished recently in the field of application; especially of high concentrations.

c) New fungicides have been developed although not as many as in the case of insecticides.

d) Control over particle size has been significant even though much remains to be done.

2) Trends

a) There is a trend toward more highly directed application, toward better understanding of the influence of random variations, toward better understanding of the air flow surrounding aircraft and helicopters, toward better control of pesticide particle size, and a better understanding of the practical value of electrostatic deposition. In the field of control methods, there is a trend toward increased specificity and shorter lifetime of ordinary pesticides, some trend toward the use of systemic insecticides and fungicides, some development of chemicals with an aerial fumigating effect, a return to the use of baited applications and development of other attractants, and a trend toward the development of chemosterilants. All these developments will undoubtedly have some impact on the future development of pesticide application equipment.

Suggested Teaching-Learning Activities

1. Use prepared plots and flats of plants infected and infested with various pathogenic organisms and nematodes to demonstrate to the students the effectiveness of selected fungicides, bactericides, and nematocides. (Do not make a detailed study at this point.)

2. Have the students bring in labels of pesticide containers and note the brands, trade names, active ingredient, company, and instructions for use.

3. In cooperation with a local grower:

   a) Determine the extent of plant diseases or nematodes on his farm or ranch.

   b) Examine the pest control program being followed on the farm.

   c) Ascertain the approximate values accruing from the use (or failure to use) pesticides to control plant disease and nematodes.

4. List all of the chemicals that are available locally for use in controlling plant disease and nematodes.

5. Determine the approximate amounts of pesticides used annually to control plant diseases at the local, state, and national level. What was the cost of these materials and about what values accrued because of their use? How much damage do you think is caused locally by not using these chemicals?

6. Conduct a survey of farms in the area. Invite farmers to relate the kinds of plant disease control programs they are using. Ascertain the problems that are attributable to disease and nematodes which are commonly encountered. Study the equipment and supplies needed on the farms to control plant diseases and nematodes.

Suggested Instructional Materials and References

Sharvelle, Eric G., The Nature and Uses of Modern Fungicides, Burgess Publishing Company, Minneapolis, Minnesota, 1961.

Thorne, Gerald, Principles of Nematology, McGraw-Hill Book Company, Inc., New York, 1961.

Plant Diseases, The Yearbook of Agriculture, U.S.D.A., Superintendent of Documents, Washington, D.C., 1953.

Stackman, E. C., and Harrar, J. G., Principles of Plant Pathology, The Ronald Press Company, New York, 1957.

Compendium of Plant Diseases, Rohm and Haas Company, Philadelphia, Pa., 1959.

II. To develop the ability to use important terms, nomenclature, definitions, tables, charts, and guides which are used in the field and also to develop the ability to perform important computations, conversions, calculations, and measurements which are commonly used by technical workers in the field.

Teacher Preparation

Subject Matter Content

Note: This unit is presented here at an early point in the study guide in order that the instructor may review it and make plans to make use of the data and information provided for herein throughout the remainder of the course. It is not intended that the unit will be taught as a separate competency, as are the other six major units of the course, but that the material provided for here will be integrated as appropriate throughout the rest of the study. The purpose of this section then is to provide for the pulling together in one place a core of information appropriate to the course.

It will be neeessary for the instructor to gather information and materials from various sources including the ones recommended in this unit.

Guidelines in the form of an outline for use in summarizing data gathered pertinent to this section are presented.

The data presented in this section of the study guide under Competency II for the course "The Use of Chemicals as Insecticides" may be useful.

SECTION ONE - General Information

THE STUDENT WILL NEED TO BE ABLE TO:

1. Make use of words, terms, and phrases appropriate to the subject matter of the course. A Glossary of Terms will facilitate this usage.

2. Perform measurements, conversions, computations, and calculations commonly used by technical workers in the field. Tables containing units of measurement and tables of equivalents of units will be useful.

   a. Tables of measurement

-- Linear measure - length

-- Square measure - area

-- Cubic measure - volume

-- Liquid measure - capacity

-- Dry measure - capacity

-- Weight measure

-- Temperature measure

-- Time measure

-- Other

b. Tables of convenient equivalents

-- Equivalent volumes - liquid measure

-- Equivalent volumes - dry measure

-- Equivalent weight/volume - liquid

-- Equivalent weight/volume - dry

-- Equivalent lengths

-- Equivalent areas

-- Equivalent weights

-- Equivalent temperatures

-- Equivalent (other)

SECTION TWO - Information Regarding Agricultural Chemicals

THE STUDENT WILL NEED TO MAKE USE OF:

1. A table which lists the common name, active ingredient, and trade name(s) of chemicals studied in the course.

   Example: EDB Ethylene dibromide Soil fume, Dow fume IO-85

2. An alphabetical listing of chemicals commonly used in the field. Information such as the trade name, name of major producer, composition, formulation, and recommended use.

   Example: D - D (Shell)

   1, 3-dichloropropene, 1, 2-dichloropropane and other related hydrocarbons; a nematocide for soil fumigation.

3. A listing of chemical materials according to the general use

   Example: <u>Nematocides</u>

   -- chloropicrin

   -- DBCP

   -- D-D

   etc.

   <u>Rust Fungicides</u>

   -- ferbam

   -- sulfur

   -- maneb

   etc.

4. Compatibility charts and tables

   a. Phytotoxicity (with plants)

   b. Chemicals (with other chemical)

   c. Physical (with other chemical)

5. Toxicity tables providing LD and LC values (both oral and dermal, acute and chronic) of chemicals studied in the course.

6. Tolerance limitations imposed by F.D.A. upon residues applicable to the subject matter of the course (i.e., herbicides, insecticides, fungicides, etc.)

What is one part per million?

Most lay people have no conception of what constitutes one part per million residue on crops. The following examples may help you make this interpretation for them:

1. One inch is one part per million in 16 miles.
2. A postage stamp is one part per million of the weight of a person.
3. A one gram needle in a one ton hay stack is 1 ppm.
4. One part per million is one minute in two years.
5. Lay your hand on the ground and it covers 5 ppm of an acre.
6. If one pound of a chemical lands on an acre of alfalfa the hay has 500 ppm. One ounce of a chemical would impart 31 ppm.
7. A teaspoon of material on an acre of alfalfa would impart 5 ppm.
8. One teaspoon of DDT drifting onto 5 acres of alfalfa puts 1 ppm in the hay, and the Federal Law says that the hay must contain none.

(Source--Western Crops and Farm Management)

SECTION THREE - Preparation of Chemicals for Use

THE STUDENT WILL NEED TO BE ABLE TO:

1. Determine whether or not materials prepared and commercially packaged can be applied directly from the container.

2. Determine the total amount(s) of active ingredient(s) contained in a chemical mixture. Mixtures may vary according to weight, volume, concentration, and formulation.

3. Make a determination of the amounts, by weight or by volume, of chemical materials of various levels of concentration to use in order to prepare a given quantity of mixture that will meet recommended or specified dosage or concentration levels. (Weights or volumes of solid or liquid chemicals required to prepare a given quantity of material of different dilutions.)

4. Interpret tables and recommendations for "concentrate" spraying.

SECTION FOUR - Preparation Necessary in Order to Secure Specified or Recommended Application Rates

THE STUDENT WILL NEED TO BE ABLE TO:

1. Compute the area of various plots of land. These plots will vary in size, shape, topography, and planting.

   a. Determine acreage of row planting which vary according to spacing.
   b. Determine total acreage of plots.

2. Determine the speed of a vehicle traveling on the land. (In miles per hour and feet per minute.)

3. Three variables affect the application rate of agricultural chemicals secured in the field - the speed of travel, the effective width of the device applying the chemical, and the total material delivered per unit of time. <u>If two of these variables are known, calculate the other in order to secure a specific application rate.</u>

   a. Calibrate sprayers, dusters, or metering devices to secure specific delivery rates.

   b. Compute the length of boom, number of outlets, or width of opening to secure specific widths.

   c. Calibrate ground speed to secure specific rate of forward travel.

4. Use tables of "Rate of Equivalents"

   Example: 1 ounce per square foot - 2722.5 pounds per acre

5. Calculate the quantity of spray per length of row (on various spacings) which will be equivalent to a specific application per acre.

6. Determine the gallons per acre required to spray orchards of different planting distances.

7. Consider the effect of particle size on drift and deposit. (Prepare spray drift and deposit table.)

<u>SECTION FIVE</u> - Information Relative to Diagnosis and Prescription

<u>THE STUDENT WILL NEED TO MAKE USE OF</u>:

1. Tables, charts, and guides which summarize situations encountered in agricultural production in which the use of chemicals is appropriate. Materials to use and methods of application are suggested.

Examples of forms used:

Plant or Soil	Pest, Disease or Condition	Causative Agent or Factor	When to Treat	What Material to Use
Alfalfa	Insect	Spotted Alfalfa Aphid	At time of planting	Thimet

Active Ingredient per Acre	Formulation	Amount Concentration Req'd por Acre	Method of Application	Remarks
1 lb.	Granules	10% 10 lbs.	Broadcast and work in soil with seed	Do not treat if there is no spotted aphid problem in the area at time of planting, if daytime temperatures are so low that winged aphids are not migrating, or when reseeding old stands of alfalfa hay.

2. Graphs, charts, tables, and other illustrative materials available and supportive of the unit under consideration

   Examples:

   a. Graphical relationships

      -- time versus residue levels

      -- rates of application versus levels of effectiveness

      -- levels of concentration versus levels of effectiveness

      -- stage of development or growth versus effectiveness of chemical control, etc.

SECTION SIX - Sources of Information

1. Extension Bulletin 312, University of Minnesota, Fungicides, Bactericides and Nematocides, 1964, is a useful resource. An

alphabetical listing of pesticides, a section on conversion factors, and a section of chemicals grouped according to the uses which are made of them generally will be especially useful.

2. Bulletin 434, The Ohio State University, Plant Disease Control in the Garden, 1963, contains many useful guides and much useful information. The section on disease identification and control is particularly appropriate. Similar bulletins and circulars are available from the respective state experiment stations and/or extension services.

3. The equipment section of the 1965 North Carolina Pesticide Manual ($1.25 - Division of General Extension, Box 5125, Raleigh, N.C.) has many useful tables, charts, sample calculations, and conversions. The information on the selection, care, calibration, and use of sprayers and dusters is timely. Much of the 145-page manual is given to outlining prescriptions for the use of various pesticides.

4. Sharvelle (The Nature and Uses of Modern Fungicides) presents an appendix containing tables of equivalents, conversion rates, tables, charts, spray formula calculations, examples of problems, drift and deposit information, acreage computations, and a glossary of terms.

5. The glossary in the back of the 1953 Yearbook of Agriculture Plant Diseases should be useful in completing this section of the study. (pp. 897-906)

6. The many tables, graphs, charts, conversions, presented by Knott, J. D., Handbook for Vegetable Growers (John Wiley & Sons, Inc.) will be of particular use to those having an interest in the subject. The section on pest control also contains much information that is appropriate to areas other than vegetable crop production.

7. The tolerance for pesticide residues in or on fresh fruits and vegetables and other plant products need to be included in this section. They can be found in the current provisions of the Federal Food and Drug Act.

III. To develop the ability to recognize and identify both pathological agents and nematodes which infest plants and soils and the damage caused by each; to understand the economic importance, kinds, and types of losses, histories and life cycles of these infectious pests.

Teacher Preparation

Subject Matter Content

Note: This unit is designed to be a review and an extension of the study of plant pathology introduced to the student in an earlier course. An attempt is made to consider the actual conditions, settings, situations, circumstances and problems encountered in the operational field in which agricultural chemicals technicians function.

1. Review

   a. The attributes and characteristics of normal plant growth and development.

   b. The role of soil fertility, soil moisture, insect control, weed competition, the elements of weather, and the use of susceptible varieties in regard to obtaining normal plant growth and development.

2. The symptoms of plant diseases

   a. A disease is a condition in which any part of a living organism is abnormal; the condition of a plant that is being continuously affected by some factor that interferes with the normal activity of the plant's cells or organs. The concept of disease is not rigidly fixed. A sharp line cannot always be drawn between health and disease in plants. The concept varies with the duration and degree of the deviation from the normal, with the extent and final effect of disorders.

   b. One way to classify diseases is according to the effects they have on plants.

      1) Annihilating effect - destruction

      2) Limiting effect - often forces a substitution of a low-value for a high-value crop in an area

      3) Devastating effect - sometimes of epidemic proportions

4) Debilitating effect - weakening - much damage can occur before symptoms become apparent

5) Disfiguring effect - malformations

c. Each of the following symptoms of some plant disease can be thought of as fitting into the classification above. (No order is intended.)

1) Wilt
2) Blight
3) Galls
4) Mildew
5) Rot
6) Atrophy
7) Lower quality product
8) Discoloring
9) Malformation
10) Reduction of growth rate
11) Hairy roots
12) Broom top
13) Lesions
14) Gums
15) Dieback
16) Stunting
17) Reduced yields
18) Shriveling
19) Decay
20) Mottling
21) Rusts
22) Root knot

d. Plant diseases are sometimes grouped on the basis of the plant part affected

1) Seed
2) Root, tubers, bulbs
3) Stem
4) Leaf
5) Bud
6) Fruit
7) Twig
8) Flower

3. Causes of plant diseases

a. Stakman and Harrar (Principles of Plant Pathology) cite the following classification of causes of plant diseases. The emphasis of this course of study is upon the chemical control of diseases and pathogenic agents including certain fungi, bacteria, virus, and nematodes.

1) Classification of causes

There are many causes and combinations of causes of plant diseases. The three broadest categories into which they can be grouped are: (1) inanimate; (2) animate; (3) viruses. These categories are subdivided in the following outline:

a) Inanimate causes

-- Soil conditions

(a) Soil moisture--deficiency; excess; fluctuating supply

(b) Physical structure--affects root penetration, water-holding capacity, aeration

(c) Oxygen supply

(d) Chemical composition--deficiency, excess, or imbalance of macro- and micronutrient elements; harmful salts; soil reaction

-- Meteorologic conditions

(a) Light--deficiency; day length

(b) Temperature--plus and minus deviations from optimum; extremes of heat and cold; fluctuations

(c) Relative humidity--drying; occasional excess

(d) Wind--mechanical injury; drying effect

(e) Torrential rain, snow and sleet--mechanical injury, especially combined with wind

(f) Hail--mechanical injury

(g) Lightning

-- Agricultural practices--mechanical injury; chemical injury by fungicides, insecticides, and herbicides

-- Industrial by-products--smelter and other fumes; smog; smoke; gases; dust from cement plants

-- Products of plant metabolism--especially in transit and storage

b) Animate causes

-- Animals

(a) Insects

(b) Nematodes

(c) Mites

(d) Higher animals--occasionally indirect causes

-- Plants

(a) Slime molds

(b) Bacteria

(c) Fungi

(d) Algae

(e) Seed plants

c) Viruses

b. The majority of the known plant diseases are caused by fungi, bacteria, and nematodes. Time should be taken at this point to review and study how the symptoms of common plant diseases caused by various factors differ from each other. Local conditions will dictate the areas to be emphasized but plant-nutrient deficiency and soil reaction symptoms are universally encountered and are often confused with symptoms of disease caused by pathogenic organisms.

4. Pathogenic organisms of fungi, bacteria, viruses, and nematodes

a. Agents of local economic importance

Study in detail the fungi, bacteria, viruses, and nematodes of importance in the local and regional area. Add to the following study guide as appropriate.

1) Common name of pathogen

2) Scientific name of pathogen

3) Type and extent of damage to crops likely if not controlled

4) Name of disease or resultant symptoms of infection

5) Important points in the life cycle of the pathogen to remember

6) Type of control program considered most effective

7) Pertinent information regarding the pathology and physiology of the pathogen

8) Economic importance of pathogen control

9) The relationships between plant disease and nutritions and the environment

5. Factors of agricultural production associated with the chemical control of plant diseases

a. Cultural practices

1) Cleanliness of tillage

2) Crop rotation practiced

3) Planting dates observed

4) Field sanitation practiced

5) Cultivation, kind, extent

6) Harvesting dates

7) Placement of one kind of crops in relation to other kinds

b. Factors related to securing a vigorous plant

1) Control of weeds, insects, rodents

2) Quality of seed bed preparation

3) Quality of seed or plant stock used

4) Selection of varieties adapted to area

5) Selection of varieties resistant to disease

6) Fertilization practices

7) Regulation and control of soil moisture

c. Environmental factors

1) Weather (wind, temperature, rainfall, relative humidity)

2) Climate

3) Soil (reaction, structure, fertility level, etc.)

4) Chemistry

Suggested Teaching-Learning Activities

1. Compile a study guide of the plant pathogens (including nematodes) that pose the greatest threat to crop production in the local area. Include entries as suggested in the unit.

2. Study different types of plant diseases which occur in the local area. Classify according to various schemes suggested in the lesson. Note the extent of injury sustained. Pay particular attention to diseases caused by pathogens.

3. Secure information, as a class assignment, from farmers, commercial pesticide company representatives, county agents, and farm advisors, pertaining to the problems most likely to be encountered in establishing a plant disease control program (a) for a particular farm, (b) for a community.

4. Collect, prepare, and send a specimen to an identification center.

5. Update and improve the collections of displays of pathological specimen prepared by the students in previous classes.

6. If a facility is available and appropriate for the use, prepare demonstrations of plant diseases caused by various forces and agents.

Suggested Instructional Materials and References

Thorne, Gerald, Principles of Nematology, McGraw-Hill Book Company, Inc., New York, 1961.

Plant Diseases, The Yearbook of Agriculture, U.S.D.A., Superintendent of Documents, Washington, D.C., 1953.

Stackman, E. C., and Harrar, J. G., Principles of Plant Pathology, The Ronald Press Company, New York, 1956.

Compendium of Plant Diseases, Rohm and Haas Company, Philadelphia, Pa., 1959.

IV. To become knowledgeable, at the technical level, concerning various chemicals used as fungicides, bactericides, and nematocides and to control pathogens and nematodes that infest plants and soils.

Teacher Preparation

Subject Matter Content

Note: This unit is one of the most important studies of the course. Examination and study is made of the technical aspects of the chemical resources available for use in the field. The understanding thus secured will serve as a basis upon which to plan and develop plant disease control programs.

1. Common types of fungicides and nematocides

   a. Classification according to use

      1) Seed protectants

         a) Chemicals applied to seeds to prevent blights, root rots, and damping off

            -- Examples: Spergon, Arasan, Orthocide 75, Panogen, Ceresan M.

      2) Foliage and blossom protectants

         a) Chemicals applied to prevent leaf spot and blossom blight diseases

            -- Examples: Captan, Ferbam, Karathane

      3) Fruit protectants

         a) Chemicals applied to prevent fruit blemishes and harvest rots

            -- Examples: Captan, Marzate, Thylate, Dithane M22

      4) Eradicants

         a) Only a few chemicals are effective in eradicating a disease once it is well established. A few fungicides are useful.

            -- Examples: Puratized, Tag, Phix, Panogen, liquid lime sulfur

5) Antibiotics

a) Applied to control diseases such as apple and pear fireblight, tobacco blue mold, cherry leaf spot, etc.

-- Examples: Agrimycin, Phytomycin, Agri-Strep

6) Soil fumigants

a) Chemicals in gas form or in the form of water soluble materials used for eradication of soil-borne disease fungi

-- Examples: Methyl Bromide, MB, Bromomethane, EDB, Chloropicrin

7) General purpose formulations

a) Chemicals applied as sprays and dusts for the control of common disease pests

-- Examples: Ortho Garden Spray, One-Package Fruit Spray, Niagara Garden Dust, etc.

b. Based on the chemical nature

1) Inorganic chemicals

2) Organic chemicals

c. Based on specific pathogen or agent intended for

1) Fungi

2) Bacteria

3) Virus

4) Nematodes

2. Formulations of Fungicides

a. Wettable Powders--a large percentage of fungicides are formulated as wettable powders; this is the form most commonly used for spray mixes. Modern wettable powders are easily wetted and disperse well in water. A wetting agent is usually present in most wettable powder formulations, but the addition of a spreader-sticker is sometimes desirable, especially on plants with glossy or waxy leaves. Agitation is generally necessary in the spray tank to keep a uniform suspension.

b. Dusts--These formulations usually contain from 4 to 10 per cent active ingredient. As their name indicates, they are usually applied in dry form as dusts.

c. Emulsifiable Concentrates--These are liquids in which the active ingredient is dissolved in a solvent. The fungicide and the solvent often will not mix with water, so an emulsifying agent is included. When these emulsifiable materials are added to water, a milky mixture is formed which is a suspension of active ingredient and emulsified solvent in the water. Fungicides are not commonly formulated as emulsifiable concentrates.

d. Granules--These are formulations of fungicides with inert materials formed into particles about the size of coarse sugar. The percentage of active ingredient is usually low as in the case of dusts. Granules have the advantage that they can be metered out in dry form more easily and accurately than dusts or wettable powders. This is important for such applications as furrow treatments. Some degree of volatility or ability to diffuse is necessary for granule formulations to be effective. Fungicides are not often formulated in this way.

e. Solutions--True solutions are formulations in which the active ingredient or a combination of active ingredient and solvent is dissolved in water. Solutions have the advantage of requiring no agitation after the formulation is added to water. However, practically all fungicide chemicals are relatively insoluble in water. When these chemicals have a high degree of solubility they may be very effective in controlling the plant pathogen, but they are generally too toxic to the plant.

f. Suspension or Slurries--These are formulations in which a dry form of the active ingredient is mixed with a liquid. Such formulations usually have a high percentage of active ingredient and thus are similar to wettable powders. They are mixed with water for final use and require agitation.

3. Chemicals used as fungicides, bactericides, and nematocides (list not complete)

a. Bactericides

1) Bordeaux mixture

2) Actidione

3) Copper - Streptomycin - Terramycin

b. Nematocides

1) Chloropicrin
2) DBCP
3) D-D
4) Dorlone
5) Ethylene bromide
6) Ethylene dibromide
7) Mylone
8) Telone
9) Vapam
10) Vidden D
11) Vorlex
12) VPM
13) Nemagon
14) Fumagone

c. Sulfur and its compounds

1) Elemental sulfur

a) Kolofog, Kolospray, Magnetic 70, 90, 95 and Sulforon

2) Lime sulfur

3) Bis (dimethylthiocarbamoyl) sulfide

a) Thiram

-- Arasan, Fernasan, TMTD, Tulisan, Tersan

4) Zinc or ferric dimethyldithiocarbamate

a) Zirom (zinc salt)

-- Zerlate, Corozate, Zirberk, Mathasan

b) Ferbam (Ferric derivative)

-- Fermate, Ferberk, Carlamate, Ferradow

5) Metallic salts of ethylenebis (dithiocarbamate)

a) Nabam (Disodium salt)

-- Dithane, D-14

b) Zineb (Zinc salt)

-- Parzate, Dithane Z-78

c) Maneb (Manganese salt)

-- Manzate

d. Copper

1) Bordeaux Mixture (Copper sulfate and lime)

2) Copper compounds (inorganic)

a) Basic sulfates, basic chlorides, oxychloride, oxides of copper, copper carbonate and copper phosphates, silicates and zeolites

-- Trade names: Basicop, Bordow, Coppatone, Cuprox, Copper A, Cuprenet, Copox, Orthocap, Copper ZO

b) Copper salts of organic acids

-- Copper stearate, salycilate, 8-hydroxy-quinolinate, naphthenate, oleate and laurate. Trade name: Cuprinol

e. Formaldehyde

1) Formalin

f. Mercury

1) Bichloride of mercury

2) Mercurous chloride (calomel)

a) Trade names: Calo-clor, Calocure, Calogreen

3) Organic mercurials

a) Ethylmercury chloride

-- Trade names: 2 per cent Granosan, 2 per cent Ceresan

b) Ethylmercury phosphate

-- New improved Ceresan, NI Granosan, Semesan, Panogen 15, Ceresan M

c) Phenyl mercury compounds (phenyl mercuric triethanolammonium acetate and lactate; phenyl-mercuric acetate, lactate and salicylate; phenylmercururea)

-- Trade names: Pulpasan, Puratized, Agrox, Agrosan C, Pentrete, Comomerc, Germisan, Merculine, Merlane, Mersolite 8

g. Zinc

1) Zinc Chloride

2) Zinc Oxide

3) Zinc Hydroxide

a) Vasco 4

h. Metallic Chromate complexes

1) Copper zinc chromate, mercury zinc chromate, calcium cadmium copper zinc chromates

-- Trade names: Crag Potatoe Fungicide 657 and Crag Turf Fungicide 531

i. Quinone Fungicides

1) Chloranil (tetrachloro-p-benzoquinone)

-- Spergon

2) 2, 3 - dichloro - 1,4 - naphthoquinone (Dichlone)

-- Phygon

j. The Phenols

1) Chlorophenols (metallic salts of mercury, lead, sodium, copper and zinc)

-- Dowicide series

2) Dinitrophenolics

-- Krenite, Elgetol, Sodium 3, Dow Spray 66

k. Heterocyclic Nitrogen Compounds

1) Glyodin (2-heptadecyl-2-imidazoline acetate)

-- Crag Fruit Fungicides 341, 341SC, Captan, Bioquin

4. Properties and characteristics of fungicides, bactericides, and nematocides

a. An appropriate study guide should be prepared to facilitate the study of each chemical's importance to the local area. Some of the items which might be included are as follows:

1) Common name(s)

2) Trade name(s) including names "sold as"

3) Chemical name or classification

4) Active ingredient

5) Formulations used/type pesticide

6) Chemical structure

7) Industrial preparation

8) Physical state (gas, liquid, solid)

9) Analysis of mixture

10) Intended use/important pathogens controlled

11) Toxicity (LD_{50} ratings)

12) Compatibility - other chemicals, plants

13) Special additives used

14) Effectiveness/specificity as a pesticide

15) Problems of application, residue, safety hazards

16) Origin

17) Phytotoxicity

18) Application/Rates

19) Precautions

20) Related mixtures and compounds

Suggested Teaching-Learning Activities

1. Prepare a kit of samples representative of the pesticides studied in this section. Classify and assemble according to the guides presented in this unit.

2. Prepare selected pesticides for use which will be representative of the different formulations studied in this part of the course.

3. Ask the class to participate in the research needed for the preparation of a comprehensive and up-to-date study guide on pesticides examined in this study.

4. Design experiments and demonstrations to show various characteristics and attributes of the various chemicals studied.

Suggested Instructional Materials and References

Nematodes and Their Control in Vineyards, Circular 533, California Agricultural Experiment Station, Davis, California, 1965.

Fungicides, Bactericides, and Nematocides, Bulletin 312, Agricultural Extension Service, University of Minnesota, 1964.

Plant Disease Control in the Garden, Bulletin 434, Cooperative Extension Service, The Ohio State University, Columbus, Ohio, 1963.

Thompson, W. T., Agricultural Chemicals, The Simmons Publishing Company, Davis, California, 1963.

The Pesticide Handbook, Editor D. EH. Frear, College Science Publishers, State College, Pennsylvania, 1961.

Farm Chemicals Handbook, Meister Publishing Company, Willoughby, Ohio, 1966.

Sharvelle, Eric G., The Nature and Uses of Modern Fungicides, Burgess Publishing Company, Minneapolis, Minnesota, 1961.

Plant Diseases, The Yearbook of Agriculture, U.S.D.A., Superintendent of Documents, Washington, D.C., 1953.

Stackman, E. C., and Harrar, J. G., Principles of Plant Pathology, The Ronald Press Company, New York, 1957.

V. To gain a knowledge and understanding of the principles and concepts underlying the use of chemicals needed to modify the effects of pathological agents and nematodes which infest plants and soils.

Teacher Preparation

Subject Matter Content

In addition to having knowledge concerning the technical aspects of the chemical resources available to control plant disease, it is also necessary for the technical worker in this field to understand the basis upon which application is made and achievement of purpose is realized. In order to be able to use these chemicals wisely, one must be familiar with the physical and biological world in which use is made of these pesticides.

1. Fungicides, bactericides, and nematocides are effective to the extent that they are used within specified limits and applied in an acceptable manner. Variables of concern pertinent to this realization include:

   a. Selection of the appropriate pesticide

   b. Form of pesticide to use

   c. Concentration to use

   d. Method of application

   e. The time to apply

   f. Placement

   g. Weather

   h. The plant

   i. Safety hazards

2. Principles underlying the use of chemicals to control plant diseases

   Note: Before proceeding with this section of the unit, the instructor may wish to review the phenomena of infection in plants. One treatment of this topic is found in Principles of Plant Pathology, Stakman and Harrar.

   a. External plant protection

1) The principle of external plant protection is based upon the acceptance of the germ theory of disease. If diseases are caused by pathogens, effort should be made to prevent infection. Attempt is made to cover the exposed surfaces of plants, with substances toxic to pathogens, but not to the plants. Four principles of external plant protection are:

   a) The destruction of large quantities of inoculum and pathogenic agents in the vicinity of crop plants reduces the likelihood of their developing disease.

   b) The destruction of spores of plant pathogens on dormant plant parts (disinfestation) reduces the infection potential of these pathogenic organisms.

   c) The application of protective sprays and dusts to growing plants destroys the pathogens present and, by residual action, prevents further attack by other pathogens subsequently deposited on the exposed surfaces.

   d) The actual disinfection of plants by surface treatments, following the attack of pathogenic micro-organisms, can be accomplished under special circumstances but is not generally practicable.

b. Internal plant protection

   1) Physiological basis for the use of systemics

      a) Many of the critical relationships between pathogen and host have been identified. Chemicals are selected and introduced into the plant in order that the relationships are interfered with in such a way as to prevent infection or the development of a pathogen in the plant.

   2) A recent development in plant chemotherapy is the use of antibiotic substances from micro-organisms. The principle or phenomenon of biological antagonisms or antibiosis of certain bacteria and fungi with other microorganisms makes possible the use of these substances. Antibiotics from the genus Streptomyces have been of greatest value thus far. It has been shown in many plants that antibiotics are absorbed and translocated throughout the plant. (Not all plants do this.) Movement in the plant has been shown to be both upward from the roots and downward through the xylem.

Sharvelle, The Nature and Use of Fungicides, pp. 147-148, reviews the actual control of plant disease by several methods through the use of antibiotics.

c. How fungicides work

1) Protective - Most of these fungicides are solids that have been ground to a specific particle size and mixed with wetting ingredients or conditioning agents to improve their physical properties.

Some fungicides are liquids which are diluted with water and applied as sprays. It is of utmost importance in using fungicides to secure a uniform application in order to secure protection. (The principles underlying the application of sprays and dusts should be understood. The instructor may want to review these with the class at this point.)

Fumigants and Nematodes

Thorne, Principles of Nematology, pp. 30-34, indicates that "the manner in which soil fumigants kill nematodes has not been determined." A number of possibilities are explored by the author with the conclusion that "it appears best to assume nematodes are usually killed by a combination of penetration through the amphides and oral ingestion." The action of fumigants in the soil and their effect upon various stages of nematodes are further considered by Thorne. In addition, he presents instructions for soil fumigation. The instructor will find a review of this literature helpful.

3. The selection of a pesticide to control pathogenic fungi, bacteria, or nematodes is dependent upon a number of factors

a. The pesticide

1) Compatibility

a) Chemical

b) Phytotoxic

c) Physical

d) Hazard to wildlife, animals

2) Toxicity

a) Oral, dermal

-- acute, chronic

3) Formulation

4) Solubility

5) Stability

6) Residue likely

7) Persistence

8) Ease of application

b. The pathogen

1) Kind

a) Fungi

b) Bacteria

c) Nematode

2) Susceptibility to pesticide

a) High

b) Moderate

c) Low

3) Point of infestation or attack most likely

a) Underground (roots, tubers)

b) Above ground (leaves, stems, flowers, fruit)

4) Developmental stage of the organism

5) Type and extent of damage likely

c. The habitat, host or likely host

1) Kind

2) Stage of growth, age, size

3) Condition of plant or soil

4) Intended use of the plant or its products

5) Part being treated

d. Environmental factors

1) Temperature

2) Relative humidity

3) Rainfall

4) Wind

5) Season of the year

4. Formulations of pesticides for controlling pathogenic fungi, bacteria, and nematodes

a. Kinds of auxiliary agents used

1) Wetting agents. Material used to assure that there will be no layer of air between a solid and a liquid (reduces surface tension of particles).

2) Spreaders. Materials used to facilitate creeping or spreading over a surface so that the area covered is increasingly greater.

a) Action, disadvantages, limitations, examples

3) Adhesives - stickers. Materials which increase adhesion of pesticides to substrates.

a) Action, disadvantages, limitations, examples

4) Deflocculating agents (dispersants). Materials which keep particles from each other to prevent flocculation and to assure dispersion and to retard settling of a solid within a liquid.

a) Action, disadvantages, limitations, examples

5) Emulsifiers. Materials used to facilitate formation or increase dispersion of one liquid within another, when one is not miscible or soluble in another.

a) Action, disadvantages, limitations, examples

6) Safeners. Materials used to counteract the chemical characteristics of a material which may normally cause phytotoxic effects.

a) Action, limitations, examples

b. In addition to those that are evident from the name, the following are other reasons for using supplemental agents:

1) To increase the penetration of the material throughout the foliage, soil, or into the pathogen

2) Reduce fire hazards

3) Secure greater product stability, especially against the effects of weather

4) Increase or secure compatibility

5) Provide for storage

6) Improve ease and economy of application

7) Improve control of residues and levels of persistence

8) Take advantage of electrostatic change

9) To take advantage of or to offset physical and chemical change that will occur

c. Theory of using auxiliary agents

1) Pesticides are

a) Liquid

b) Solid

c) Gaseous

2) Liquid sprays are used as

a) Water or oil emulsions

b) Water suspensions of solid particles

c) Water-base emulsions

3) Definitions and concepts of action (extend as appropriate)

a) Solutions

b) Emulsions

c) Surface tension, density, viscosity

d) Wetting and spreading

e) Drop size and sprayer efficiency

f) Synergism/antagonism

d. Using other pesticides with fungicides, bactericides, and nematocides

1) The need to combine pesticides

2) Compatible mixtures

3) Incompatible mixtures

4) Examples of incompatibilities

5. Application

a. Effective plant disease control programs through the use of chemicals is dependent upon

1) A knowledge of pathogenic organisms

2) A knowledge of host plants and the infectious effects of pathogenic organisms upon such plants

3) A knowledge of chemicals used to control pathogens

4) The utilization of proper equipment to make possible the use of selected materials

5) The proper use of application equipment in order to secure effective results in the field of application

b. Kinds of applications

Advantages and disadvantages, the appropriate use which should be made, and the limitations should be examined for each of the following:

1) Complete sprays

2) Droplet or mist sprays

3) Dusts

4) Aerosol fog

5) Fumigants and gaseous applications

c. Methods of application of fungicides

1) Seed Treatment - Fungicides applied to seed may be formulated as dusts, wettable powders, solutions, or

suspensions. The formulation and method of application should give uniformity of coverage to seed and a minimum of danger and irritation to the operator. Seed may be treated in batches with simple equipment or continuously with special machines.

2) Spraying - The greatest amount of fungicide used is applied in the form of spray to leaves, fruit, and stems of plants. Wettable powders are most commonly used for preparing sprays, although emulsions or solutions may be used in some cases.

3) Dusting - Dusts are applied to leaves, fruits, and stems of plants as an alternative to spraying.

For garden use, many people prefer dusting from the standpoint of convenience. A duster can be filled easily and used without the trouble of mixing sprays and cleaning out the sprayer after each use. However, a sprayer generally gives a better application.

For field applications, many people prefer sprays for maximum coverage of plants; others prefer dusts because the machinery is lighter and can be used under more adverse ground conditions. Dusting equipment is usually lower in cost than sprayers, but dust is more expensive than spray material on a per-acre basis. Sprayers can be used in higher wind velocities than dusters, but dusters have the advantage of requiring no water. Sprays generally do not bother the operator as much as dusts.

4) Drenching - Fungicides are sometimes made up with water at about the same concentration as for spraying and applied to the soil surface either before or after plants emerge. This method is used to control damping off, root rots, or infections at the ground line.

5) Furrow Treatments - Fungicides may be applied either as dusts or with water to the furrow at planting time. Such treatment is for control of diseases that occur at the base of the plant. Special equipment must be built or purchased for such application.

6) Planter or Hopper Box Treatment - Certain fungicides, applied as dusts, are added to the seed and mixed in the planter box. They control seed- and soil-borne diseases. No special equipment is needed for such application and risk of treating excess seed is eliminated.

7) Soil Fumigation - Application of certain materials to the soil can control fungi and nematodes. Such materials usually produce a gas that distributes itself through the soil. Some impervious cover which confines the gas to the soil for a limited period of time is usually required; in some cases a water seal is sufficient. Such treatments are usually restricted to small areas and high-value crops.

8) Dips - Fungicides are sometimes made up in concentrations similar to those for spraying and are used for dipping plants or propagative parts before they are planted.

9) Fungicide Paints - Fungicides are occasionally mixed with water, alcohol, or other carriers and applied as a paint on a wound surface. For example, Bordeaux mixture can be made up to paint-like consistency by mixing a prepared Bordeaux mixture powder with linseed oil for use in painting tree wounds. This is sometimes recommended for use on pruning cuts to control fire-blight of apples and pears.

d. Time of application

Only by understanding the principles and concepts pertaining to the timeliness of applying pesticides can program planning be completed. Instructors should direct the preparation of a study guide which treats important considerations of the local area. Some of the points to be considered in the preparation of the guide might include:

1) Considerations regarding the pathogens

a) At what point in time will they be present

b) How long do they remain

c) At what point in time will the pathogen be most susceptible to chemical control treatments

d) How is the pathogen affected by residues

e) Will beneficial forms of life be harmed

f) What is the location of the infestation on the plant likely to be

2) Considerations regarding the plant

a) Is the plant at a stage of growth where it is likely to be injured from the use of the pesticide

b) What is the condition of the plant

-- How much new growth since last application

-- What is the density of the foliage

-- What is the nature of the surfaces

3) Other considerations

a) Temperature

b) Relative humidity

c) Rainfall/dew

d) Wind

e) Temperature inversions

f) Equipment available for application

g) Form and concentration of insecticide to be used

h) Kind of insecticide to be used

Suggested Teaching-Learning Activities

1. Demonstrate various kinds of incompatibilities as well as various compatibilities.

2. Apply various pesticides to different kinds of pathogens and study the results.

3. Apply various pesticides to different crop plants (under controlled conditions) and note the protective action against various pathogens.

4. Prepare various kinds of formulations for use to control fungi, bacteria, and nematodes.

Suggested Instructional Materials and References

Sharvelle, Eric G., The Nature and Uses of Modern Fungicides, Burgess Publishing Company, Minneapolis, Minnesota, 1961.

Stackman, E. C., and Harrar, J. G., Principles of Plant Pathology, The Ronald Press Company, New York, 1957.

Thorne, Gerald, Principles of Nematology, McGraw Hill Book Co., Inc., New York, 1961.

Compatibility charts.

Samples of supplementary agents.

Pesticide materials.

VI. To acquire the skills and abilities needed in the general use of pesticides to control pathogenic fungi, bacteria, viruses and nematodes which infest plants and to become familiar with specific practices of plant disease control in local areas.

Teacher Preparation

Subject Matter Content

Planning a program of plant disease control through the use of chemicals and its subsequent implementation makes use of knowledge, understanding, and abilities gained and developed during this and related courses. A most important activity of the agricultural chemicals technician is making practical applications of theoretical understandings.

Planning a program for controlling plant diseases by the use of chemicals assumes that other methods of control have been considered and evaluated in terms of the specifics applicable.

Guidelines for program planning are suggested. The instructor will need to modify and adapt to fit local circumstances as deemed necessary.

1. Guide for planning a control program

   a. Determine what the situation is at present and what it is likely to be if pesticides are not used

      1) What damage is likely to result?

      2) What is the threat of pathogenic organisms?

      3) What risk is involved?

      4) What degree of control can be expected?

      5) What resources are available for use?

      6) What are the alternatives within the chemicals field?

   b. Establish goals and objectives

      1) Establish what is desired, and what is to be attempted

         a) Is it possible, attainable?

         b) Is it challenging yet worthwhile?

         c) What tools of measurement are to be used; how will we know of our progress?

2) Spell out goals and objectives in terms of:

a) The crop or crop product

b) The pathogen

c) The use of necessary inputs

d) The control to be exercised over other variables

c. Spell out ways and means to accomplish goals and objectives - devise a plan of action

1) Establish priorities and allocate resources

a) Determine the operational framework

b) Spell out limitations

c) Ascertain the specific use to be made of pesticides (refer to the previous unit for study guide which was to be developed)

d) Make a selection of the material(s) to be used

e) Plan for the use of the pesticide

-- Determine the form of pesticide to use

-- Ascertain the appropriate time application will be made

-- Select the method of application

-- Plan for the <u>proper</u> preparation of the materials for application

-- Detail the <u>proper</u> application to be made

f) Plan an evaluation procedure to review the results obtained

2. Aids to program planning

a. Educational materials relating to plant disease control programs are readily available in every state. While there have been recent advancements in the development of new chemicals for use in the general field of plant diseases, the number of new products is not large as is

the number developed for use as insecticides. Fewer authors have treated the topic of "chemicals and plant diseases" than have treated "chemicals and insects." However, many aids appropriate to the subject of concern are available.

A number of states endeavor to publish and revise a pesticide manual each year. Personnel from research, enforcement, extension, industry, teaching, and advising contribute to the preparation of these guides. The 1965 North Carolina Pesticide Manual is an excellent example.

Each of the major agricultural chemical companies is concerned with the promotion of their products. Many such firms prepare handbooks and other materials which report the very latest recommendations by leading entomologists, chemists, and pathologists.

b. Instructors should request lists of publications and other educational materials related to plant diseases from:

1) U.S.D.A. - Superintendent of Documents

2) State Cooperative Extension Service

3) Agricultural Experiment Stations

4) Commercial Publishing Companies

5) Commercial Chemical Firms

6) Commercial Trade Association Offices

7) Professional and Vocational Associations

8) Educational Materials Centers

c. Types of materials available include:

1) Texts and reference books
2) Handbooks
3) Guides
4) Leaflets
5) Circulars
6) Bulletins
7) Film strips
8) Movie film
9) Charts
10) Laboratory manuals
11) News releases
12) Magazine articles
13) Lectures
14) Reports
15) Fact sheets

d. Information and data provided in many of these educational materials are useful in assisting a person to:

1) Identify disease-causing organisms

2) Describe symptoms of infestation and attack by pathogens

3) Plan a control program

a) The control of a specific pest

b) The control of pests which attack a specific kind of plant

c) The control of pests which infest similar plants

d) The control of pests which infest a large group of plants

e) The control of pests which infest a specific part of a host

f) The control of pests grouped according to:

-- Order, genes, species, etc.

-- Feeding method

-- Method of reproduction

-- Habitat

-- Feeding habits

g) The control of pests according to the use of chemicals belonging to specialized groups (fumigants, organic, oils, etc.)

3. General information and data with regard to:

a. Fungicides

1) The sulfur fungicides

2) The copper fungicides

3) The mercury fungicides

4) The carbonate fungicides

5) The gyoxalidine fungicides

6) The quinone fungicides

7) The quanidine fungicides

8) Miscellaneous fungicides

b. Nematocides

c. Bactericides

d. Seed treatment

e. Soil treatment

f. Field and forage crops

g. Fruit and nut crops

h. Ornamentals and flowers

i. Vegetable crops

Suggested Teaching-Learning Activities

1. Select a farm nearby and, with the cooperation of the owner, plan a comprehensive program of plant disease control.

2. Randomly select six or eight farms in the area and survey them as to the kind of plant disease control programs being practiced. Develop suggestions for improvements.

3. Devise a study guide and information sheet for the chemical control of plant diseases common to the area.

4. Invite representatives from local agricultural chemical firms to review approved practices of plant disease control in the area.

Suggested Instructional Materials and References

Educational materials as available from the sources listed in the unit.

VII. To acquire the knowledge and skills needed to handle, transport, store, and apply lawfully and safely those chemicals used to prevent, control, or eradicate pathogenic fungi, bacteria, and nematodes which infest plants.

Teacher Preparation

Subject Matter Content

The concern for safety and need for laws and regulations in the field of fungicides, bactericides, and nematocides.

NOTE: The unit developed under this heading and included in the study guide for the course "The Use of Chemicals as Insecticides - Plants" is appropriate to this course if emphasis is placed upon the provisions dealing with diseases, fungicides, and nematocides instead of upon insects and insecticides as was done for that course.

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INSTRUCTOR NOTE: As soon as you have completed teaching each module, please record your reaction on this form and return to the above address.

1. Instructor's Name_____

2. Name of school_____State_____

3. Course outline used: _____Agriculture Supply--Sales and Service Occupations
   _____Ornamental Horticulture--Service Occupations
   _____Agricultural Machinery--Service Occupations

4. Name of module evaluated in this report_____

5. To what group (age and/or class description) was this material presented?____
   _____

6. How many students:
   a) Were enrolled in class (total) _____
   b) Participated in studying this module _____
   c) Participated in a related occupational work experience program while you taught this module _____

7. Actual time spent teaching module:

		Recommended time if you were to teach the module again:
_____hours	Classroom Instruction	_____hours
_____hours	Laboratory Experience	_____hours
_____hours	Occupational Experience (Average time for each student participating)	_____hours
_____hours	Total time	_____hours

(RESPOND TO THE FOLLOWING STATEMENTS WITH A CHECK (✓) ALONG THE LINE TO INDICATE YOUR BEST ESTIMATE.)

	VERY APPROPRIATE	NOT APPROPRIATE
8. The suggested time allotments given with this module were:		
9. The suggestions for introducing this module were:		
10. The suggested competencies to be developed were:		
11. For your particular class situation, the level of subject matter content was:		
12. The Suggested Teaching-Learning Activities were:		
13. The Suggested Instructional Materials and References were:		
14. The Suggested Occupational Experiences were:		

(OVER)

15. Was the subject matter content sufficiently detailed to enable you to develop the desired degree of competency in the student? Yes_____No_____
Comments:

16. Was the subject matter content directly related to the type of occupational experience the student received? Yes_____No_____
Comments:

17. List any subject matter items which should be added or deleted:

18. List any additional instructional materials and references which you used or think appropriate:

19. List any additional Teaching-Learning Activities which you feel were particularly successful:

20. List any additional Occupational Work Experiences you used or feel appropriate:

21. What do you see as the major strength of this module?

22. What do you see as the major weakness of this module?

23. Other comments concerning this module:

_____ _____
(Date) (Instructor's Signature)

_____
(School Address)